HSE
Fire Safety Engineering Team

FCC Performance-based safety design

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Performance-Based Analysis

In the process of defining project alternatives for the cross section of the FCC tunnel, safety aspects should be also be included.

However, because of the unique nature of this infrastructure, the prescriptive requirements specified in the applicable legislative references often appear inappropriate.

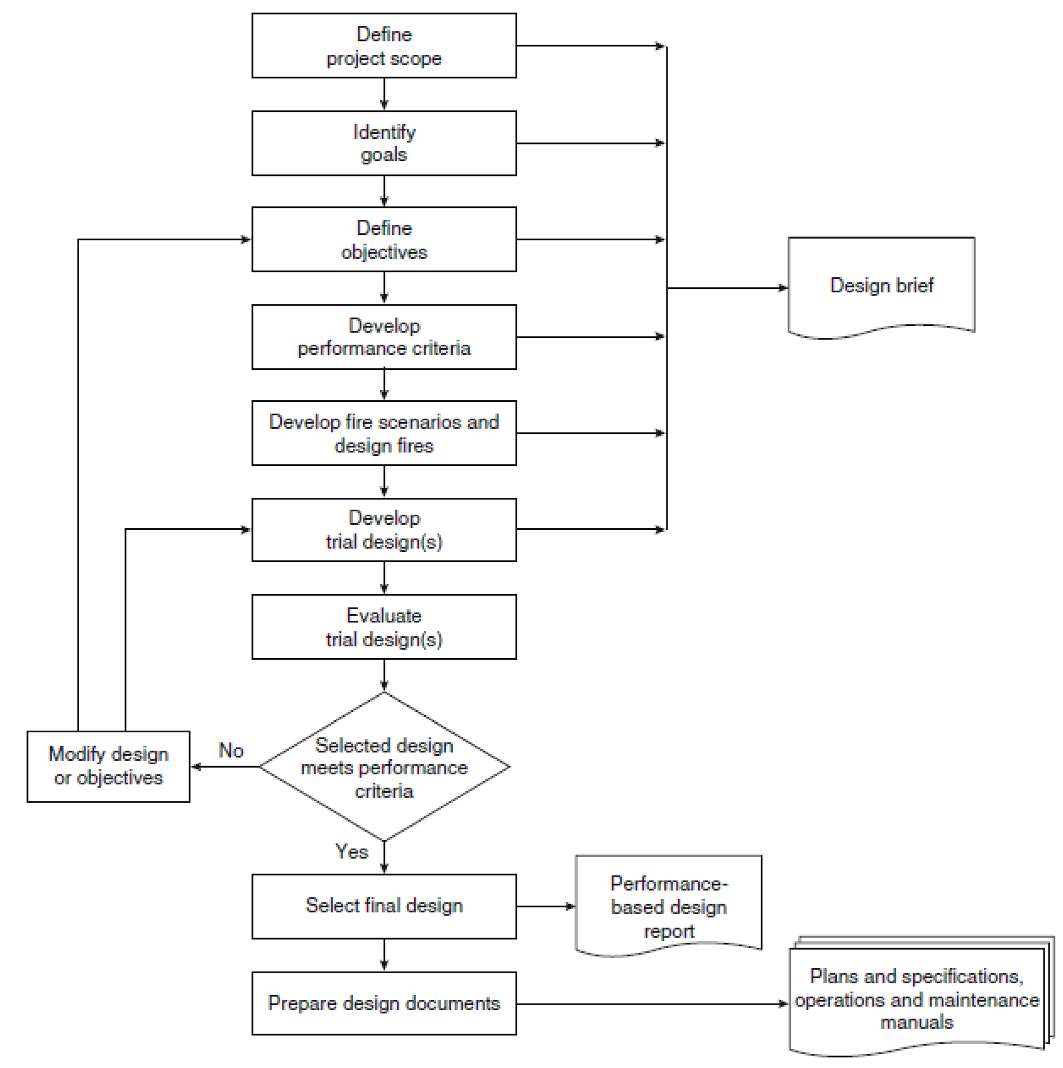
For this reason, CERN's HSE unit has proposed to extend the application of the performance-based approach, originally developed for fire safety, to other safety domains. This poster provides an overview on how this approach can be applied at CERN.

Once that the project scope is established, in this case the definition of the FCC tunnel cross section, the process foresees to identify the safety goals. They are formulated in general terms and based on CERN's safety policy as well as on other equivalent documents (French labor code, Swiss norm of fire protection, Construction Products Directive). Based on these goals, safety objectives are defined in order to better detail and clarify what already expressed in the design goals.

The proposed methodology then foreseen the identification of the hazards for each project phase where a performance-based assessment is necessary (it is here assumed that some hazards can be tackled simply applying standard best practices).

The following step would be the definition of specific scenarios, related to the above-mentioned hazards. Scenarios should describe the characteristics of building/safety systems, occupants and hazard. They are used to evaluate the trial designs.

Different methodologies of trial design evaluations, of increasingly high complexity, can be used. For a preliminary design, a qualitative analysis can be conducted. Finally, trial designs fulfilling the safety objectives for each hazard and design phase are retained.



Source: SFPE Engineering Guide to Performance-Based Fire Protection

Step 1 - Define Safety Goals

The Safety Goals shall be in line with the Organizations' Safety Policy:

- Life safety;
- Environmental protection;
- Property protection;
- Continuity of operations.

Step 2 - Define Safety Objectives

For each of the Safety Goals, design objectives need to be clearly defined

- Life safety;
  - Occupants shall be able to evacuate through protected areas, free from smoke and other hazards at any time;
  - …
- Environmental protection;
  - Limit the release of polluting agents to the environment (e.g. activated smoke in case of fire) in case of incident;
  - …
- Property protection;
  - Limiting the property loss in case of incident (e.g. in case of fire cleaning, recabling, replacing damaged equipment);
  - …
- Continuity of operations
  - Limiting the downtime in case of incident.

Step 3 - Define Hazard Registry

List of Hazards that exist in each of the most important phases of the FCC life-cycle:

- Installation
- Commissioning (Hardware & Beam)
- Operation
- Maintenance (including technical stops)
- Long Shutdown
- Dismantling

Hazards for which a performance-based design is needed are identified (e.g. Fire, helium release, etc.)

Step 4 - Define Accidental Scenarios

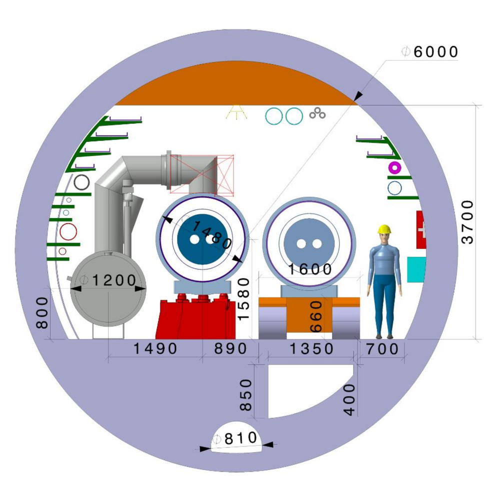
List a series of accidental scenarios that will be tested against the design trials (see step 5).

E.g.:

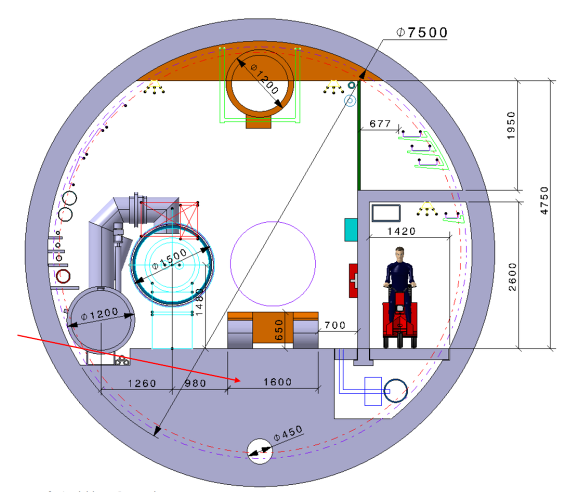
Scenario description (Fire1): wooden pallets are ignited by a welding activity, occupants in the vicinity are not able to extinguish the fire, one of them is injured and needs to be evacuated, fire detection is not yet installed, no sound alarm is given, ventilation stays on, most of the occupants (say 40) are located downstream, fire brigade is alerted via mobile phone, the fire propagates to cable drums and cable trays under installation.

Step 5 – Define Trial Designs

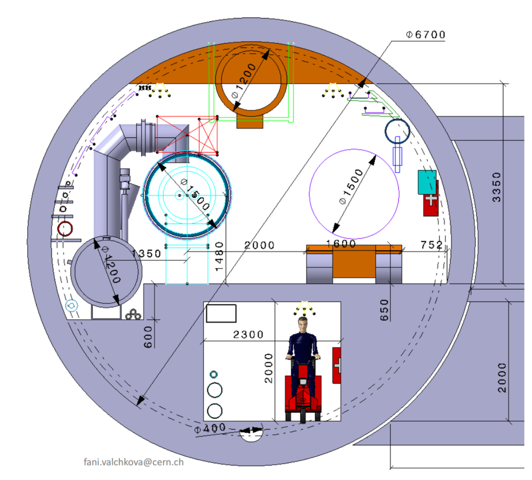
Trial #1



Trial #2

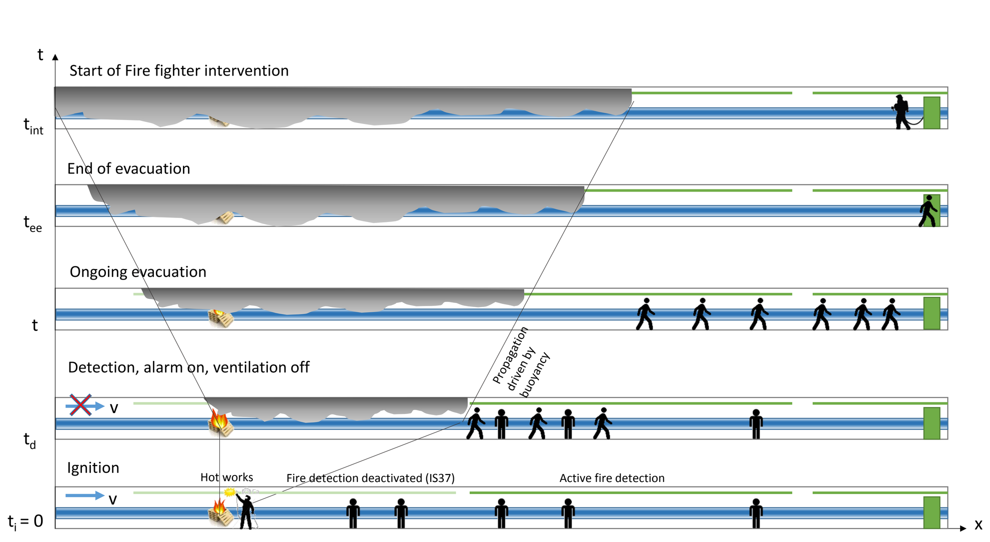


Trial #3



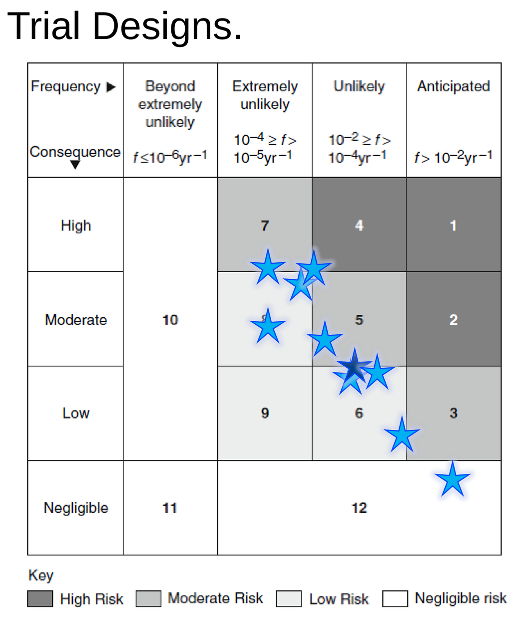
Step 6 – Evaluate Trial Designs

Different approaches, of increasingly high complexity, can be taken for the evaluation of the Trial Designs.

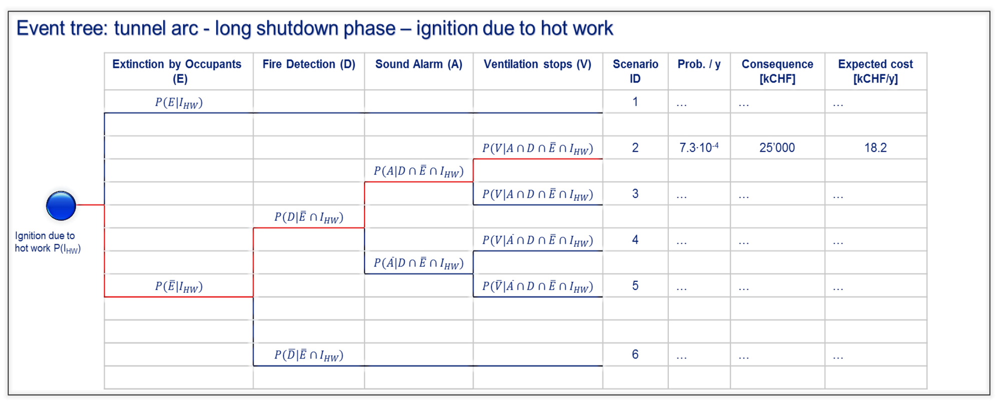


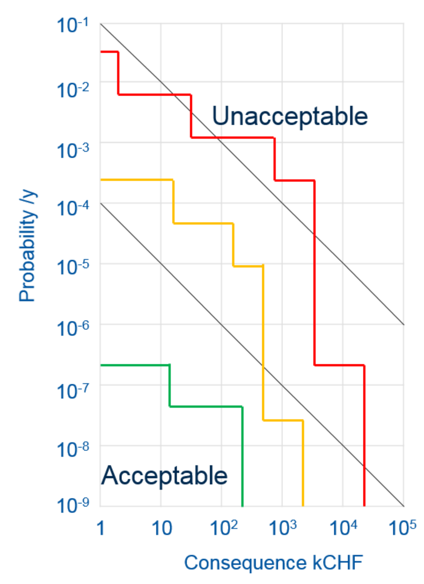
Qualitative approach

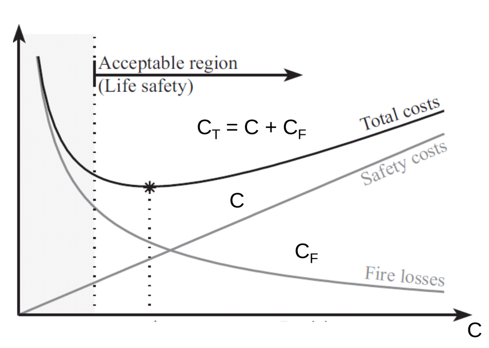
Scenario	Prob. per year	Consequence kCHF	Expected cost kCHF / y
Fire initiated by hot works and extinguished by occupants	10^{-1}	1	0.1
Fire initiated by equipment failure (e.g. in alcove during operation) and propagation	10^{-2}	100	10
Large propagating fire during long shutdown	10^{-4}	200'000	20
Fire initiated by hot works and not extinguished by occupants	**$7.3 \cdot 10^{-4}$**	**25'000**	**18.2**
Release of activated smoke to the environment	10^{-5}	1'500	0.015
…	…	…	



Simplified Probabilistic approach (risk matrix)







Full Probabilistic approach

Conclusion

- A performance-based design methodology is general enough to be applied to all the different project phases and to different hazards
- Several risk assessment methods of increasing level of detail, including risk matrices were presented;

Works Cited

- SFPE engineering guideline to performance-based fire protection, second edition, SFPE;
- SFPE handbook of fire protection engineering